Dimension reduction for PDE using local Karhunen Loeve expansions

Sandia National Laboratories

University of Utah

SAND2015-7990R

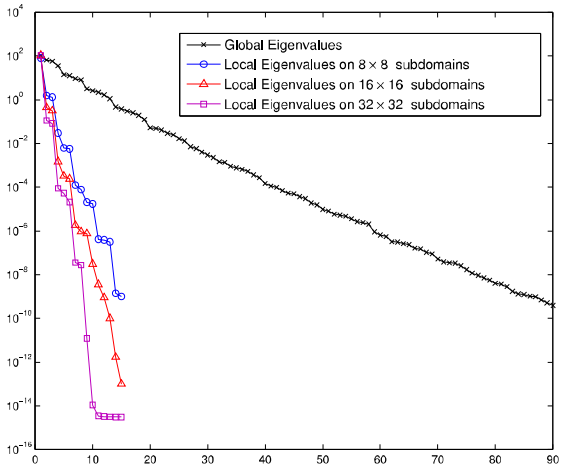
Yi Chen, Dongbin Xiu (Utah); John Jakeman (SNL); Claude Gittelson

Objectives

- Develop efficient methods for sampling linear partial differential equations subject to uncertain random fields
- Use domain decomposition and local Karhunen Loeve expansions (KLE) to represent a random field with small correlation length with local KLE defined over subdomains with relatively larger correlation lengths.
- Show the use of local KLE reduces the high dimensional global field to a set of lower dimensional KLE

Impact

- Method is composed of highly independent sub-problems and could potentially be very suitable to large HPC systems
- Facilitates rigorous uncertainty quantification and predictive simulation improvements for high-fidelity linear PDE



Comparison of the eigenvalue decay of a global KLE with the decay of local KLE on subdomains of varying mesh resolution

Accomplishments

- Method results in significant dimension reduction when solving local problems
- Demonstrated that dimension reduction can be leveraged to reduce the computational expense of solving linear PDE subject to high-dimensional random fields.
- Provides at least one order of magnitude reduction in the total computational cost of generating sets of simulations for varying parameter values.

U.S. DEPARTMENT OF ENERGY | Office of Science

QUANTIFICATION OF UNCERTAINTY IN EXTREME SCALE COMPUTATIONS QUEST

Sandia National Laboratories is a multi-program laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.